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ABDUCTION THROUGH GRAMMAR, CRITIC, AND METHODEUTIC

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Introduction

Abductive inference is nowadays a controversial issue, despite its application in a variety of fields. In philosophy, logic, and artificial intelligence, some researchers have taken a great deal of interest in it (see, e.g., Josephson & Josephson 1994; Niiniluoto 1999a; Flach & Kakas 2000a; Magnani 2001; Aliseda 2003). But the concept has its critics: Some have maintained that it is not a viable mode of inference, especially if abduction is presented as a logic of *discovery* (Frankfurt 1958; Kapitan 1990, 1992). So it seems that abduction brings forth and conceptualizes issues that are highly important; according to Hintikka, abduction is "the fundamental problem of contemporary epistemology" (Hintikka 1998); but still, the exact nature of abduction is a contentious matter.

In this article I maintain that the character of abduction can be clarified by taking into account Peirce's distinction between three areas of logic or semeiotic, that is, the distinction between *grammar*, *critic*, and *methodeutic*. Abduction is often analyzed from the point of view of *critic*, which concentrates on the validity and justification of abduction, an important perspective that should not be neglected. Yet by itself, it is too narrow an approach. I maintain that *grammar* and *methodeutic* are especially important in abduction because it is so weak a mode of inference. These three perspectives on abduction should not be seen as strict alternatives. One can better understand the nature of abduction, by looking at the interplay among the three areas within logic.

My starting point in this article is Peirce's writings concerning abduction and semeiotic in general. But my aim is not so much to present a historical analysis of Peirce's own ideas but rather to reformulate and use Peirce's ideas to further develop abduction. Peirce's writings can be and have been developed in various directions. His later views of abduction, for example, strongly emphasized the *instinctual* character of abduction. I maintain, however, that by developing grammatical, and especially methodeutical aspects of abduction, an alternative interpretation of abduction can be presented. This gives also a new means to understand and defend abduction as a weak form of inference that is important in

discovery, i.e., as a logic of discovery.

The Phases of Peirce's Abduction

Peirce's writings of abduction[1] are a rich source of ideas and inspiration for the modern reader. Peirce was always developing his ideas in relationship to many related themes, i.e., to logic, to theory of signs, to human cognition, to metaphysical principles. Even Peirce's views at some particular time are more like a cable with a variety of arguments than a single line of an argument for some particular view.[2] Still, there are some main trends or periods on Peirce's development.

It is customary to discern two main periods in Peirce's conceptions of abduction (Burks 1946, 301; Fann 1970, 9-10, Thagard 1981; Anderson 1987, 19-23; Flach & Kakas 2000b, 5-8). In the early period Peirce saw abduction mainly as an *evidencing process* (Burks 1946; see e.g., CP 2.623, 1878). According to this view abduction is a weak form of (syllogistic) inference, which has its basis on an inversion of the deductive syllogism, so that it is an inference of the minor premise from the major premise and the conclusion. The emphasis is on the relationship between the premises and the conclusion, and how this relationship is different in cases of abduction in contrast to induction and deduction. According to Burks, the later period started sometimes after 1891. Abduction was then seen from the *methodological perspective* rather than as an evidencing process (ibid.; see e.g., CP 7.202-219, 1901). It means that abduction is seen as a first phase of inquiry, followed by deduction and induction. According to this view ideas are generated and adopted with abduction, and then they are explicated and tested with deduction and induction.

This was not an abrupt change in Peirce's conceptions (Burks 1946, 301; Anderson 1987, 19-20). There are early formulations which have much similarity to the methodological perspective:

> "Yet it is hypotheses with which we must start; the baby when he lies turning his fingers before his eyes is making a hypothesis as to the connection of what he sees and what he feels. Hypotheses give us our facts. Induction extends our knowledge. Deduction makes it distinct." (W 1:283, 1865; see also W 1:186, 1865)

On the other hand, there are later formulations, which emphasize the evidential and syllogistic nature of abduction:

> "… [A]bduction is the inference of the truth of the minor premiss of a syllogism of which the major premiss is selected as known already to be true while the conclusion is found to be true." (CP 8.209, c. 1905; see

also CP 5.189; 1903)

The change from the evidential viewpoint to the methodological viewpoint was concomitant with the idea that we humans have to have a sort of "abductive" instinct that helps us to find and guess hypotheses. Peirce's argument goes roughly as follows (CP 7.220, 1901; HP 2:900-901, 1901; CP 5.591, 1903): We could not have reached our theories and scientific knowledge by chance. There simply is not enough *time* in human history that it could have happened by chance. So it seems that we have to have some sort of an instinct that helps us to find good hypotheses and ideas. And when animals have various instincts at their birth, for example for finding food, why not to assume that we humans can have an instinct for finding correct theories. This instinct is not supposed to be infallible, but it is, according to Peirce, strong enough to have helped us to find out true hypotheses or ideas. Peirce had, then, various alternative grounds for this instinct in his writings; these grounds varied from naturalistic and biological, to metaphysical and idealistic, or also to theistic grounds (Shanahan 1986; see e.g., CP 8.209-12, c. 1905).

As a matter of fact, the supposition of an abductive instinct is perhaps a clearer mark of change in Peirce's view than the change from the evidential perspective to the methodological perspective as such. In his early formulations, instincts had no role within abduction. In 1883 Peirce in passing presented the idea that we humans have an instinct for guessing right, but he did not connect it then to abduction; on the contrary, he rejected this connection (CP 2.749-754, 1883). In his later writings, he said that this instinct is precisely the root of abduction (see CP 8.234, c. 1910; cf. CP 2.102, c. 1902). This guessing instinct is then one central element in all Peirce's later conceptions of abduction. The idea is that abductive instinct has an essential role in the first phase of inquiry where ideas are developed.

The former evidential (or syllogistic) conception of abduction was not enough for Peirce because it does not take into account the basis for new ideas, i.e. our abductive capability for guessing right hypotheses. It can be said that Peirce's early view of abduction means that abduction, along with induction, belongs to the context of *justification* whereas according to the later view, abduction is placed in the context of *discovery* (Thagard 1981[3]). According to the early view, although abduction was seen as a weak form of inference, the emphasis was on how the conclusion can be drawn from the premises. The idea of *discovery* was not an issue in these formulations. In his later writings (in the methodological phase), abduction was explicitly connected to the generation of new ideas. According to Peirce, new ideas cannot be originated by deduction or induction but only by abduction; "[a]bduction furnishes all our ideas concerning real things, beyond what are given in perception" (CP 8.209, c. 1905, see also CP 5.145, 5.171-172, 1903; CP 2.776-777, 1902; CP 5.590, 1903; CP 6.475, 1908).

Although Peirce's later view emphasizes abduction as the first phase of inquiry, there is at least two main ways of interpreting this conception in relationship to discovery (see Fann 1970, 41-42). These are closely connected to later debates concerning abduction as a "logic of discovery" (see, e.g., Frankfurt 1958, 594; Nickles 1980, 18-23; Brown 1983, 399-400, 404; Kapitan 1992). Some formulations of Peirce seem to emphasize abduction as a way of both *generating* new ideas and also of *evaluating them in some preliminary way*. This seems to be Peirce's conception, especially around the turn of the century:

> "*The first starting of a hypothesis and the entertaining of it*, whether as a simple interrogation or with any degree of confidence, is an inferential step which I propose to call abduction." (The emphasis added, CP 6.524-525, 1901; see also CP 7.202, 1901)
>
> Or:
>
> "The first stage consists in *the invention, selection, and entertainment of the hypothesis*. This I call the abduction." (The emphasis added, HP 2:895, 1901)

Later formulations emphasize abduction more as a way of *generating* new ideas, without an explicit emphasis on any further evaluation. In 1901 Peirce had written that two kinds of considerations tend toward an expectation that a given hypothesis may be true, both instinctive and reasoned (CP 7.220, 1901). But later when the generative sense of abduction is emphasized, the instinctive reasons become more predominant: "… by Retroduction [i.e. abduction] … that is to say, by the spontaneous conjectures of instinctive reason" (6.475, 1908), or "… what I mean by a Retroduction [i.e., abduction] is simply a conjecture which arises in the mind" (NEM 3:203-204, 1911). But this seems to be a change of emphasis at most because there are later writings by Peirce where both the generative and evaluative sense of abduction are important:

> "The whole series of mental performances between the notice of the wonderful phenomenon and the acceptance of the hypothesis, during which the usually docile understanding seems to hold the bit between its teeth and to have us at its mercy, the search for pertinent circumstances and the laying hold of them, sometimes without our cognizance, the scrutiny of them, the dark labouring, the bursting out of the startling conjecture, the remarking of its smooth fitting to the anomaly, as it is turned back and forth like a key

> in a lock, and the final estimation of its Plausibility, I reckon as composing the First Stage of Inquiry. Its characteristic formula of reasoning I term Retroduction [i.e. abduction], i.e. reasoning from consequent to antecedent." (CP 6.469-470, 1908)

In other words, although Peirce is here describing the first phase of inquiry whose *characteristic* formula is abduction, it seems to apply to abduction. Both "the bursting out of the startling conjecture" and "the final estimation of its Plausibility" are then elements of abduction.[4]

The main periods of Peirce's conception of abduction are then the evidential/justificatory period and the methodological/discovery/instinctual period. The latter period can be divided into two, emphasizing either the generation phase or the generation with the preliminary evaluation. These are, however, only main outlines of Peirce's abduction, and by using the distinction of grammar, critic, and methodeutic, other aspects of abduction can be brought to the fore.

Trivium of Grammar, Critic, and Methodeutic

Peirce discerned a trivium of logic, or semeiotic throughout his career (Liszka 1996, especially pp. 9-11). The names for the three areas changed over the years, and the formulations also varied (see Bergman & Paavola 2003-), also because his conception of logic and semeiotic changed somewhat throughout the years. In his early formulations, these areas were called '*formal grammar'* (or '*general grammar'*, or '*universal grammar'*), '*logic'* (or '*general logic')*, and '*formal rhetoric'* (or '*general rhetoric'*, or '*universal rhetoric'*) (W 1:258, 1865; W 1:274, 1865). A typical characterization is the following:

> "… [L]ogic treats of the reference of symbols in general to their objects. In this view it is one of a trivium of conceivable sciences. The first would treat of the formal conditions of symbols having meaning, that is of the reference of symbols in general to their grounds or imputed characters, and this might be called formal grammar; the second, logic, would treat of the formal conditions of the truth of symbols; and the third would treat of the formal conditions of the force of symbols, or their power of appealing to a mind, that is, of their reference in general to interpretants, and this might be called formal rhetoric." (CP 1.559, 1867)

Here, logic is the middle area between formal grammar and formal rhetoric, and it concerns only symbols.

Later Peirce broadened his conception of logic to deal with semeiotic in general, and then this trivium was a distinction *within* logic that concerns symbols, indices, and icons. This is not, however, a radical difference to his earlier views because the middle part was still seen to be the main area of logic (EP 2:326-327, 1904). In these formulations, the first part was often called '*speculative grammar*' (also '*stecheotic*', or '*analytic*'), the second part '*logic*', or '*critic*' (or '*logical critic*'), and the third '*speculative rhetoric*', or '*methodeutic*' (e.g., EP 2:19, 1895; CP 1.444, c. 1896; CP 2.93, 1902; CP 4.9, c. 1906; NEM 3:207, 1911). The following characterization is a good representative of Peirce's later view:

> "All thought being performed by means of signs, logic may be regarded as the science of the general laws of signs. It has three branches: (1) *Speculative Grammar*, or the general theory of the nature and meanings of signs, whether they be icons, indices, or symbols; (2) *Critic*, which classifies arguments and determines the validity and degree of force of each kind; (3) *Methodeutic*, which studies the methods that ought to be pursued in the investigation, in the exposition, and in the application of truth." (EP 2:260, 1903)

I am *not* going into detail, here, concerning this distinction. It has affinities, for example, to a more familiar distinction in logic between syntax, semantics, and pragmatics (Liszka 1996, 10); also for historical reasons. I am using this distinction as a sort of heuristic background in order to point out some elements or characteristics of abduction. So, I am not aiming at clear-cut definitions for these areas, but using them as a way of highlighting some central viewpoints regarding abductive inference.

The area of *methodeutic* (or *rhetoric*) is perhaps the most difficult part of Peirce's trivium to characterize; grammar and critic are easier. According to the customary interpretations, that is backed up by Peirce's own formulations, *grammar* concerns such things as the theory and the classification of signs, and *critic* concerns the area of formal logic and the theory of three main modes of inference, i.e. abduction, induction, and deduction (e.g., Liszka 1996, Santaella-Braga 1999). Methodeutic seems to be the vaguest and the most underdeveloped part in Peirce's own writings; neither has the area been analyzed very often in the secondary literature (Liszka 1996, 78-108; Santaella-Braga 1999; Bergman 2000). This underdevelopment seems to be the case although Peirce also remarked that this third part of logic is "what the greater part of my life has been devoted to, though I base it upon Critic." (NEM 3:207, 1911). One difficulty with methodeutic is that it seems to include so many and various aspects within itself that is difficult to see the overall nature of it (Bird 1959; cf. Peirce

himself: CP 2.207, 1901). It seems, for example, that Peirce himself wanted to use the terms ‘methodeutic’ and ‘speculative rhetoric’ interchangeably (see CP 2.93, 2.105, c. 1902; CP 4.9, c. 1906). Still, his characterizations of 'methodeutic' concerns such things as *inquiry*, and the attainment of *truth* (CP 2.207, 1901; EP 2:260, 1903; NEM 3:207, 1911) whereas the characterizations of 'speculative rhetoric' concerns *signs more generally*, *interpretants*, and transmission of *meaning* (EP 2:325-330, 1904; CP 1.444, c. 1896). So I would like to use these terms so that ‘speculative rhetoric’ is a more wider concept entailing meanings and interpretants of all varieties whereas ‘methodeutic’ is a narrower concept that focuses on logic and on the attainment of truth (cf. Liszka 1996, 79, 98-108; Santaella-Braga 1999, 388-393; Bergman 2000, 245-247; see also Bird 1959, 190-193).

The typical distinction of grammar, critic, and methodeutic (presented above) is good as far as it goes. But it is problematical when it comes to using it for analysing abduction (or various modes of inference in general). In this distinction, abduction is seen only through critic. What are missing are the grammatical and methodeutical aspects of abduction. I agree that the point of view of critic is essential for abduction, but it has, however, dominated discussion too much. A broader perspective on abduction opens up, when grammar and methodeutic are taken explicitly into account. They bring forth aspects of abduction that are essential in order to understand the nature and usefulness of abduction. They also help to put critic to a new perspective.

In this article these three areas of semeiotic are understood roughly as follows: 1) *grammar* that focuses on the nature and meaning of categories and sign relationships within abduction, 2) *critic* that concerns the validity and strength of abduction, and 3) *methodeutic* which analyzes abduction from the processual point of view and as a part of processes of inquiry, and how abductive inferences are used for certain purposes.

2. Critic(al) Questions

Although critic is the middle part in Peirce’s trivium, it can be taken first because of its importance for logic, and also because it seems to be the clearest area to characterize. It focuses on the strength and the validity of abduction, essential issues in abduction. Abduction is a weak mode of inference, but how weak? And is there any hope that it could be a *valid* mode of inference in any sense? If it is not valid, its status as a form of inference is problematic (Kapitan 1990, 1992).

Peirce analysed and developed abduction, the third mode of inference in various writings over a period that lasted almost 50 years (starting at least from 1865; see e.g., W 1:266-267, 1865; and continuing to the end of his life; see e.g., CP 8.385-388, 1913). Peirce was always seeking to further develop his ideas. It is no wonder then, that Peirce’s writings contain elements of various interpretations of abduction.

One often-cited formulation of abduction is the beanbag-example, which brings forth the difference between deduction, induction, and abduction. It is from the early period when Peirce saw abduction from the evidential, or syllogistic point of view.

DEDUCTION.
Rule.--All the beans from this bag are white.
Case.--These beans are from this bag.
.·.Result.--These beans are white.

INDUCTION.
Case.--These beans are from this bag.
Result.--These beans are white.
.·.Rule.--All the beans from this bag are white

HYPOTHESIS. [ABDUCTION]
Rule.--All the beans from this bag are white.
Result.--These beans are white.
.·.Case.--These beans are from this bag."
(CP 2.623, 1878)

If deduction is an inference of a result from a rule and a case, induction can be presented as an inference of a rule from a case and a result, and abduction (or 'hypothesis' as it was then called by Peirce) is an inference of a case from a rule and a result.

Another basic formula of abduction (See Peirce, CP 5.189, 1903; Hanson, 1958, 86) is the following:

The surprising fact, C, is observed;
But if A were true, C would be a matter of course,
Hence, there is reason to suspect that A is true.

This is a more general scheme than the syllogistic form above (Niiniluoto 1999a, S439) and belongs to the later period.

These formulations by themselves do not tell very much about the nature of abduction, not even from the point of view of critic. Critic concerns the validity and strength of abduction. Is the conclusion supposed to be inferred as a probability, or with plausibility, or with possibility, or what (cf. Niiniluoto 1999a)? I think it is clear that according to Peirce abduction is a weak mode of inference (e.g., CP 2.625, 1878; CP 2.102, 1902; CP 5.188, 1903; CP 8.385-388, 1913). Peirce presented, however, abduction with different strengths in various writings. Especially in his earlier works, he presented it often as a form of probabilistic reasoning. For example:

Hypothesis

Any *M* is, for instance, *P′ P″ P‴*, etc.
S is *P′ P″ P‴*, etc.;
∴ *S* is ***probably*** *M*."
(The emphasis added; CP 2.511, 1867; see also CP 2.706-707, 1883)

In his later writings, however, Peirce rejected these probabilistic formulations. He maintained that he had mixed up abduction (i.e., 'hypothesis') and induction in various writings before the turn of the century (CP 8.227-228, c. 1910; see also HP 2:876-877, 1900). He wrote that abduction does *not* deal with probabilities:

> "I fell into the error of attaching [a name the synonym I then used for] Abduction, to a probable inference which I correctly described, forgetting that according to my own earlier and correct account of it, abduction is not of the number of probable inferences." (HP 2:1031-1032, 1902; see also RLT 141-142, 1898; CP 2.102, c. 1902)

Peirce is *not* saying that those inferences, which he had presented in these earlier formulations, were invalid but they are not abductions, but "abductive *inductions*" (or something similar) (see HP 2:1031-1032, 1902). Abductive inferences would be weaker than these abductive inductions.

In his later writings, Peirce consistently held that abduction is a *very weak* mode of inference. Peirce maintained, for example, that abduction is only guessing, or asserts "its conclusion only problematically or conjecturally" (CP 5.188-189, 1903; HP 2:878-879, 1900; CP 7.219, 1901; HP 2:898-899, 1901; CP 2.776, 1902; NEM 4:319-320, c. 1906; NEM 3:203-204, 1911), abduction "merely suggests that something *may be*" (CP 5.171-172, 1903; NEM 3:203-204, 1911; see also CP 8.229, 8.238, c. 1910); abduction states its conclusion *interrogatively* (HP 2:878-879, 1900; HP 2:898-899, 1901; CP 6.525, 528, 1901; EP 2:287, 1903; CP 6.469-470, 1908). Or, abduction states the conclusion to be "plausible" (CP 6.469-470, 1908; see also CP 8.222-223, c. 1910). Some of his early formulations also presented abduction as a very weak form of inference:

> "As a general rule, hypothesis is a weak kind of argument. It often inclines our judgment so slightly toward its conclusion that we cannot say that we believe the latter to be true; we only surmise that it may be so" (CP 2.625, 1878; see also e.g., W 1:283, 1865).

In the article "A Neglected Argument for the Reality of God" (1908) Peirce characterizes how the conjecture arises in the "First Stage of Inquiry" (where abduction is central); here the inquirer

> "is led to regard his conjecture, or hypothesis, with favor. As I phrase it, he provisionally holds it to be "Plausible"; this acceptance ranges in different cases -- and reasonably so -- from a mere expression of it in the interrogative mood, as a question meriting attention and reply, up through all appraisals of Plausibility, to uncontrollable inclination to believe." (CP 6.469, 1908)

There is a variety of possible strengths for abductive conclusion here, but plausibility for Peirce meant something that is related to the conjectural nature of abduction. In a letter to Paul Carus, Peirce makes a distinction between "plausibility, verisimilitude, probability" as "the three different kinds of acceptability of propositions" and continues: "[b]y plausibility, I mean the degree to which a theory ought to recommend itself to our belief independently of any kind of evidence other than our instinct urging us to regard it favorably" (CP 8.222, c. 1910; cf. Brown 1983, 404-409; Rescher 1995). Abduction is a very weak mode of inference, even when it leads to an "uncontrollable inclination to believe" the conclusion.

Another issue in critic, besides strength, is the validity and the justification of abduction. A basic criticism against abduction is that it is not a valid mode of inference, and it is not even clear what *kind* of criteria should be applied to abduction (in contrast to deduction and induction). According to Fann, the validity of abduction is one of the most unsatisfactory features in Peirce's theory (Fann 1970, 54). In his later writings Peirce often analyzed this problem but it seems that he was never fully satisfied with the answers. Peirce offered various candidates for this validity (Fann 1970, 51-54; Kapitan 1992, 3-5, 22 (note 6); Kapitan 1997, 489). These candidates range from the idea that deduction is the only rationale for all reasoning, and thus also for abduction (CP 5.146, 1903), to the idea that abduction "needs no reason, since it merely offers suggestions" (CP 5.171, 1903).

Peirce's later views about justification were intimately linked to the idea that there is a natural tendency for us humans to find true hypotheses, i.e., that our abductive instinct is the basis for the justification of abduction (see e.g., CP 6.474-477, 1908). Such a basis, however, creates a fundamental problem. Peirce maintained that abduction can be at the same time reasoning and a process with its basis in an instinct. But it is not easy to see how this could be so (Fann 1970, 35-38; Anderson 1987, 32; Kapitan 1990, 503-507; Kapitan 1992, 8; Rescher 1995; Hoffmann 1999, 294-298). And what is the basis for supposing that we really have this kind of an instinct? It should be remarked that

sometimes Peirce presented the instinct explanation for abductive success explicitly as a *hypothesis*, which indicates that he was not fully satisfied with it (CP 7.39, c.1907; CP 7.220, 1901; CP 1.121, c.1896; see Fann 1970, 37, 54). I maintain that we can have alternatives for this hypothesis, which are good candidates for explaining our abductive capabilities. In any case, some explanation is needed if it is maintained that abduction is a weak form of inference, which does *not* have its basis in pure chance. We have to have some means of controlling our abductive guesses (Burton 2000). Otherwise it is hard to see how abduction can be of any use. But this requires that grammar, and especially methodeutic, be taken into account.

3. Grammar: the Meaning of Firstnesses in Abduction

What about grammar in abduction? Grammar should be a propaedeutic, i.e., a preliminary study for critic (CP 2.206, 1901; CP 2.83, c. 1902; cf. NEM 3:207, 1911). It seems that, for Peirce, grammar includes such things as the whole classification of signs, his theory of signs, and before these, the doctrine of the categories, i.e., his phenomenology (see e. g., CP 2.83-99, c. 1902). What are missing, however, in these typical characterizations of grammar, are grammatical elements *within* abduction. Neither did Peirce himself, at least explicitly, bring forth this viewpoint. It seems that grammar, for Peirce, concerns more the nature of signs *in general*, and how the categories are the basis for signhood and for various classifications of signs. Peirce did, however, discuss the nature and the meaning of categories, as well as the meaning of various kinds of sign-relationships within the three forms of inference without using the term 'grammar' explicitly. It could then be maintained that they are essential aspects of grammar for abduction.

Peirce's tripartite classification of modes of inference (deduction, induction, and abduction) was clearly in accordance with his mature system of three *categories* (of three categories, see e.g., CP 5.66, 1903; CP 8.328, 1904). Still, Peirce had some wavering to which categories *deduction* and *induction* would mainly belong, and the debate still continues (see CP 5.146, 1903; PPM 276-277, 1903). The issue is if deduction is related to Thirdness, and induction to Secondness; or deduction to Secondness, and induction to Thirdness (Staat 1993). But in relationship to abduction there were no such waverings. It seems to be clear that abduction was always connected to the First category according to Peirce (Staat 1993; Turrisi 1990; cf. also Thagard 1981, 272)[5].

It is, however, not clear what the element of Firstness means in abduction. Peirce himself claimed that when he had mixed up abduction and induction in his earlier writings, his *categories* furnished the clue that helped him to see this relationship more clearly, and so helped him better to understand the nature of abduction (CP 2.102, c. 1902; see also HP 2:1034, 1902; Turrisi 1990). I suggest that the element of Firstness means that *iconicity* is especially important in abduction, which also means that abduction is a weak mode of inference (it

"merely suggests that something may be"). Peirce says this clearly in some of his characterizations of abduction: "Now, I said, Abduction, or the suggestion of an explanatory theory, is inference through an Icon, and is thus connected with Firstness …" (PPM 276, 1903). Abduction is then only a *suggestion* with its element of Firstness. Or another passage:

> "An originary Argument, or *Abduction*, is an argument which presents facts in its Premiss which present a similarity to the fact stated in the Conclusion, … so that we are not led to assert the Conclusion positively but are only inclined toward admitting it as representing a fact of which the facts of the Premiss constitute an *Icon*." (CP 2.96, c. 1902; see also EP 2:287, 1903; W 1:485, 1866; CP 1.559, 1867)

It should be remarked that Peirce emphasized iconicity of reasoning on the whole, not only in respect to abduction (Hintikka 1997, 23-28). An essential element in mathematical reasoning is its diagrammatic, and so iconic, nature (e.g., NEM 4: 353, 1893; NEM 4: 275, c. 1895; NEM 4: 158, 1903). This is also, according to Peirce, the reason why mathematical and deductive reasoning, which draw necessary conclusions, can still present surprising discoveries. Mathematical reasoning involves observational elements, and the reasoner is supposed to *see* something when she reasons (CP 5.148, 1903; Hintikka 1997, 24).

> "The truth, however, appears to be that all deductive reasoning, even simple syllogism, involves an element of observation; namely, deduction consists in constructing an icon or diagram the relations of whose parts shall present a complete analogy with those of the parts of the object of reasoning, of experimenting upon this image in the imagination, and of observing the result so as to discover unnoticed and hidden relations among the parts." (CP 3.363, 1885)

Iconicity is only one element in reasoning, and both icons, indices, and symbols are needed in "perfect system of logical notation," but iconicity is especially important in bringing the element of *discovery* to reasoning (ibid.; see also NEM 4:366-368, n.d.).

In abductive inference, iconic relationships are especially important. Abduction is inference "through an Icon" in contrast to induction and deduction, which are inference "through an Index" and "through a Symbol" (PPM 276, 1903). But how does this iconic relationship then

operate in abduction? In his early paper “On a New List of Categories” Peirce writes:

> “In hypotheses [i.e. abduction], something like the conclusion is proved, that is, the premisses form a likeness of the conclusion. Take, for example, the following argument:
>
> M is, for instance, PI, PII, PIII, and PIV;
> S is PI, PII, PIII, and PIV:
> .·. S is M.
>
> Here the first premise amounts to this, that "PI, PII, PIII, and PIV" is a likeness of M, and thus the premises are or represent a likeness of the conclusion." (CP 1.559, 1867)

I think that a better statement of this relationship is from 1901: "The mode of suggestion by which, in abduction, the facts suggest the hypothesis is by *resemblance*, -- the resemblance of the facts to the consequences of the hypothesis." (CP 7.218, 1901) So the iconic relationship is between some facts or phenomena stated (P1) and the consequences (P2) of a hypothesis suggested (H1); and the abductive conclusion is that this kind of a hypothesis (H1) may be true (in relationship to those facts (P1)).

P1
H1 -> P2 } An iconic relationship between P1 and P2

.·. Maybe H1 (or something that is similar to H1) [6]

The close relationship to iconicity is also one reason why abduction is closely related to *perceptual* judgments according to Peirce (CP 5.181-194, 1903; cf. Hanson 1958; Hoffmann 1999). It also means that things like small details, characteristics, and tones have an important role in abductive inference. Abduction is often described as a form of reasoning that *detectives* use (Fann 1970, 56-59; Eco & Sebeok 1988; Niiniluoto 1999b). That is so because detectives are typically trying to find hypotheses or interpretations that would explain some mysterious events or facts. In these situations, small details and features have an important role. For detectives, clues are not just some facts that need explanation, they are rather facts with some peculiar characteristics and details, and these small details and tones are often the crucial incitement both for seeing that something is wrong in these facts (that needs then explanation and further

inquiry), and for using these clues to help in finding new explanations (cf. CP 2.776, 1902). In this sense, the element of Firstness means that detectives are using these often hazy features as a heuristic aid when they are trying to find new explanations and interpretations abductively. But this broader perspective requires that methodeutic is also taken into account.

4. Methodeutic (1): the First Phase of Inquiry with the Economy of Research

Peirce had various characterizations of methodeutic. It “shows how to conduct an inquiry” (NEM 3:207, 1911). It "studies the methods that ought to be pursued in the investigation, in the exposition, and in the application of truth" (EP 2:260, 1903). It means "the principles of the production of valuable courses of research and exposition" (EP 2:272, 1903), and "considers not what is admissable but what is advantageous" (HP 2:1035, 1902). As I said earlier, I am not trying to define the area of methodeutic. But I maintain that Peirce’s characterizations of methodeutic means that it considers abduction from the *processual point of view*, and as *a part of processes of inquiry* in general. This is a methodological viewpoint on abduction where *heuristical* aspects (and strategical aspects – see below) and the *use* of abductive inference are taken into account. Methodeutic is closely connected to *interpretants* and *purposes* which signs aim to determine (CP 2.93, 1902; NEM 4:62, 1902; Bird 1959, 189-191; Liszka 1996, 104-108).

In his later writings, Peirce emphasized a methodeutical viewpoint where abduction was seen as the *first* phase of inquiry. Ideas are suggested with abduction, made clearer by using deduction, and then tested by using induction (CP 6.469-473, 1908; CP 7.202-219, 1901). This methodeutical viewpoint gives one answer how abduction can be a very weak mode of inference (cf. Thagard 1981). Peirce wrote about abduction that "[i]ts only justification is that from its suggestion, deduction can draw a prediction which can be tested by induction" (CP 5.171-172, 1903; see also CP 7.218-219, 1901; PPM 282-285, 1903). It is not supposed to be a way of getting true hypotheses necessarily or by itself. Abduction can be a weak form of inference if it is supposed to be a way of getting *suggestions* that need to be tested before the acceptance.

But if abduction gives only suggestions, it is open to the criticism that it is not very useful. One basic criticism against abduction has been that it leaves room for “wild” hypotheses (e.g., Frankfurt 1958, 597-8; Achinstein 1970; 1971). It seems that by using the basic formula of abduction (and a bit imagination) almost anything at all can be inferred. Abduction should be a way of finding *good* hypotheses and suggestions for further testing; not all possible suggestions. Instead of trying everything the inquirer should have a way of finding promising candidates. In this sense abduction is closely linked to heuristics and the *economy of research*. According to Peirce the economy of research is especially important in abduction.

> "Abduction cannot be absolutely bad. For sincere efforts to reach the truth, no matter in how wrong a way they may be commenced, cannot fail ultimately to attain any truth that is attainable. Consequently, there is only a relative preference between different abductions; and the ground of such preference must be economical. That is to say, the better abduction is the one which is likely to lead to the truth with the lesser expenditure of time, vitality, etc." (NEM 4:37-38, 1902; see also CP 7.220n18, 1901; RTL, 141-142, 1898)

But how to get good and promising suggestions instead of all kinds of suggestions? Peirce's main answer is the (abductive) *instinct* that helps us humans to find good hypotheses: "it is a primary hypothesis underlying all abduction that the human mind is akin to the truth in the sense that in a finite number of guesses it will light upon the correct hypothesis" (CP 7.220, 1901). But besides these instinctive reasons there are the *"reasoned"* considerations that should be taken into account (ibid.) These reasoned considerations are especially important in those formulations of Peirce where abduction was clearly seen as a way of generating new ideas *and* at the same time of evaluating them in a preliminary way; and here the *economy of research* is essential. In 1901 Peirce listed three economical factors: caution, breadth, and incomplexity (ibid.; Kapitan 1997, 484). Caution means the skill of breaking the hypotheses in such a way that each test divides the possibilities as effectively as possible, so that all possibilities will be tested as effectively as possible (As Peirce mentions, the well-known game of twenty questions has its basis on this idea). Breadth means that it is economical to try to make the hypothesis apply to many phenomena, if it is otherwise reasonable. Incomplexity means that it might be economical to try a simpler hypothesis first even if more complicated ones could be nearer to the truth, if the simpler hypothesis is more instructive with reference to next steps in inquiry.

It should be remarked that when Peirce is talking about the economy of research in the reasoned sense (i.e., besides the instinctual sense), and methodeutic, it is about the preliminary evaluation of which hypothesis to put to the test (Fann 1970, 47; Kapitan 1997, 481; see also HP 2:879, 1900). For example, in some of his writings, Peirce maintained that the methodeutical perspective is especially needed in abduction (cf. Santaella-Braga 1999, 393-394).

> "Methodeutic has a special interest in Abduction, or the inference which starts a scientific hypothesis. For it is not sufficient that a hypothesis should be a justifiable one. Any hypothesis, which explains the facts, is justified

> critically. But among justifiable hypotheses we have to select that one which is suitable for being tested by experiment." (NEM 4:62, 1902; HP 2:1035, 1902)

Here the selection of hypotheses to be tested is just the task of methodeutic. According to this view, methodeutic starts when the generation of hypotheses has somehow already happened.

I think that the meaning of methodeutic could be broadened from these formulations to include those processes where hypotheses and new ideas are generated in the first place. It seems that Peirce himself appealed mainly to instinct in his later writings when it comes to explain the generation of new hypotheses; and such an appeal excluded methodeutical processes. This phase is then described as a sudden moment of discovery, for example, as "an act of insight" which "comes to us like a flash" (CP 5.181, 1903), or as "the spontaneous conjectures of instinctive reason" (CP 6.475, 1908). But I maintain that in Peirce's writings there are also elements for a different interpretation concerning methodeutical aspects of abduction. Methodeutical considerations can also help when hypotheses are searched for in the first place, that is, they can point out those intermediate phases that belong to the abductive search for good or promising hypotheses. But this requires that *strategical* aspects of inference be considered.

5. Methodeutic (2): Taking Strategies into Account

As I have interpreted it in this article, the methodeutical viewpoint means that the *processes* of reasoning are emphasized. Methodeutic also means that the purpose of the inquiry has to be taken into account, and how to achieve this purpose. I have maintained that according to Peirce's later view, the purpose of abduction is to help in generating plausible (or good candidate) hypotheses which should then be tested by deductive and inductive means (PPM, 282-284, 1903). It can then be suggested that one important aspect of methodeutic is the use of *strategies* (Paavola, in press; cf. Hintikka 1998).

Jaakko Hintikka has emphasized a distinction between two sorts of rules in reasoning and logic: the *definitory rules* and the *strategic rules* (e.g., Hintikka, 1999). The definitory rules tell what are valid rules in particular system of logic. By analogy: the definitory rules of chess tell what one is allowed to do in chess (how chessmen may be moved and so on). But by knowing only the definitory rules of chess one cannot say that one plays chess well. Excellence in chess requires that one knows *strategic* rules extremely well, i.e. knows how to play chess well, and what is worth doing in particular situations.

I am not using the concept of "strategies" in a strict sense. As I understand strategies here, they are related to a plan and to an art of achieving a goal that requires a coordination of various actions and moves in order to achieve this goal.

The use of strategies means that this goal influences the way how these moves are put together; what is the order of various moves; when or whether something should be taken into account, for example. Good strategies give advice about what is worth doing, not just tell what one is allowed to do (this latter being the area of the definitory rules by using Hintikka's concepts).

Peirce did not use the concept of "strategy" explicitly in his writings, but he had other ways of emphasizing strategical aspects of reasoning, which are especially important in abduction (Paavola, in press; Hintikka 1998, 515). Peirce's characterization of abduction in the context of methodeutic is strategical: "Of the different classes of arguments, abductions are the only ones in which after they have been admitted to be just, it still remains to inquire whether they are advantageous" (HP 2:1035, 1902). As was shown in the previous chapter the economy of research requires that various factors can be taken into account when hypotheses are selected in a preliminary way for testing. But what about strategies when hypotheses are generated in the first place? I maintain that strategies show themselves at least in two ways, 1) in how anomalies are chosen as the starting point for abduction, and 2) in taking many inferential moves into account at the same time.

Peirce often described abduction as starting from *surprising*, *curious* or somehow *anomalous* phenomena (e.g., CP 2.624, 1878; HP 2:878-879, 1900; EP 2:287, 1903; CP 5.189, 1903). But why is that? What is the difference for trying to explain non-anomalous facts (cf. Aliseda 2000; Hoffmann 1999, 281)? Would it not be a better idea to try to explain *all* the relevant information instead of anomalous phenomena? I think that this is a strategical point that is closely related to the economy of research. It would be impossible, or at least very time-consuming, to try to explain everything, even everything that is somehow relevant to the situation in question. So it is a strategical choice to concentrate on some curious phenomena, and hope that by explaining them, the whole case will be solved (This is like searching out the weak points of the opponent in games with two, opposing sides). So although it is possible to start abductive inference from non-anomalous phenomena, it is often a good strategical point to concentrate on anomalous phenomena. These surprising, or anomalous phenomena can be just some small, disturbing details that do not seem to fit into the overall picture of the situation. One reason why abduction is often compared to the reasoning that detectives use is the idea that the basic strategy of detectives is to use these minute details as clues when searching for explanations.

Methodeutic means that the whole process of abductive inference should be taken into account. Not just the validity of abductive inference is important, but also, for example, how premises of abductive inference are found or searched for, or when and how these premises are utilized in reasoning. In this sense, abduction is only relatively speaking the *first* phase of inquiry. Abduction starts from facts and is a search for explanations (CP 7.218-219, 1901). Experience

and facts, especially anomalous or surprising phenomena, suggest hypotheses and give hints for explanations (ibid., CP 2.755, c. 1905; CP 6.469, 1908; Burton 2000, 154-155). From a methodeutical point of view it is important how these anomalous phenomena turn up although they do not influence the validity of abduction. Phenomena are anomalous or surprising only in relationship to the inquirer's previous knowledge or background theories (see Aliseda 2000). Abductive inferences are then a part of an ongoing cycle of research where the abductive search for new ideas and theories, the deductive explication, and the inductive testing of theories are closely intertwined.

Strategies mean also that when an inferential move is made, the overall goal and other moves should be taken into account. Thus, from the methodeutical point of view, abduction typically does *not* start from only *one* anomalous phenomenon, although this is the way it is presented in some best-known formulations of abduction (e.g., CP 2.624, 1878; CP 5.189, 1903). Instead, many facts are taken into account at the same time, which help to anticipate potential counter-arguments, and which also can assist the search for hypotheses. I think that N. R. Hanson was aiming at this kind of strategical thinking when he delineated abduction as a way of searching the *type* of the hypothesis with the goal of trying to find a *pattern* in the whole situation (Hanson 1965, 47-65; see Paavola in press; Niiniluoto 1999a, S440-441). Although the *trigger* for abductive search can be one anomalous or surprising phenomenon, the reasoner also has to take into account other information, in order to have an effective or fruitful abductive search (see EP 2:287, 1903). Only one anomalous phenomenon as a starting point without any other information would mean that this phenomenon could be explained potentially in a multitude of ways, and this would ruin the economy of research. There being only one such phenomenon is also an unrealistic assumption in most actual cases. The search is usually constrained and assisted, explicitly or implicitly, by various assumptions and pieces of background explanation.

Peirce had formulations of abduction that fit well with this kind of strategical thinking where many facts have to be taken into account at the same time. So although the basic formulations of abduction make the start from one anomalous phenomenon, other formulations of Peirce do present abduction as starting from consideration of many facts, for example:

> "A mass of facts is before us. We go through them. We examine them. We find them a confused snarl, an impenetrable jungle. We are unable to hold them in our minds. We endeavor to set them down upon paper; but they seem so multiplex intricate that we can neither satisfy ourselves that what we have set down represents the facts, nor can we get any clear idea of what it is that we have set down. But suddenly, while we are poring

> over our digest of the facts and are endeavoring to set them into order, it occurs to us that if we were to assume something to be true that we do not know to be true, these facts would arrange themselves luminously. That is abduction." (PPM 282-283, 1903; see also HP 2:898-899, 1901; CP 8.209, c. 1905) [7]

The idea of strategies was not explicit in these formulations of Peirce and here the new idea is suggested by a sudden insight. Along the same lines of thought, Peirce, elsewhere, has the reasoner "poring over a digest of the facts" (see above), or carrying on a dialogue with oneself, or entertaining a "Play of Musement" (CP 6.452-465, 1908). In the processes mentioned, the reasoner is at the same time using all the facts as a medium and as an aid in searching for a hypothesis (Burton 2000, 153-155). So the idea is *not* just that the reasoner finds candidate explanations and then tests them with other facts one after another, but clearly these other facts help when the hypothesis is searched for in the first place.

The use of strategies is an alternative explanation (in contrast to an abductive instinct) for the mystery of how human beings can and do find good hypotheses with such success, and come up with promising ideas for further testing. The use of strategies is also a way of answering one basic criticism against abduction as a logic of discovery, that is, how abduction can be a logic of discovery if the hypothesis that should be the *result* of the inference, is already supposed to be known in the premises (the explanatory hypothesis is in the second premise in the basic formula of abduction) (e.g., Frankfurt, 1958, 594; Nickles, 1980, 23; Anderson 1987, 33-35; Kapitan 1990, 499-503; Hoffmann, 1999, 278-9). Even though the difficult part in discovery can be to find good and right premises, the process of discovery can be abductive, *if* abductive strategies guide the process, and if the form of the inference is abductive (see Paavola, in press). Although the form of abduction as such does not guarantee that the reasoner finds the fruitful premises, and although abduction is not a mechanical way for finding good hypotheses, the strategies of abductive inference can guide the search for new ideas. In that sense, abduction *can* be the logic of discovery, even though the hypothesis is in the premises.

Conclusion: Various Forms of Abduction

In philosophy, especially in the philosophy of science, the concept of abduction is nowadays used at least in two main ways. The one concerns the issue of the "logic of discovery". This could be called the "Hansonian abduction": although N. R. Hanson was not first to introduce this idea, he was firmly defending and developing abduction to this direction in 1950s and 1960s (e.g., Hanson 1958; 1961; 1965). Hanson used Peirce's formulation of abduction against the inductivist and the hypothetico-deductive models of inquiry in order

to argue for the idea that processes of inquiry can be also analyzed rationally and conceptually. According to Hanson, inquiry starts from observations and data and not from hypotheses as the hypothetico-deductive model has maintained. But this does not mean the old inductivist model either, but an abductivist model where the ongoing search for explanations is essential. After Hanson, there has been a great deal of debate whether these abductive formulations of the logic of discovery are tenable.

The other, but related, use for the concept of abduction could be called the "Harmanian abduction" because it starts especially from Gilbert Harman's writings concerning the model of the "Inference to the Best Explanation" (IBE-model) (e.g., Harman 1965). The IBE-model concentrates more on *justification* than Hanson's concept of abduction, because the basic idea is that after comparing various alternative candidates for explanation we are entitled to say that the best one is true:

> "In making this inference one infers, from the fact that a certain hypothesis would explain the evidence, to the truth of that hypothesis. In general, there will be several hypotheses which might explain the evidence, so one must be able to reject all such alternative hypotheses before one is warranted in making the inference." (Harman 1965, 89)

Peirce's own conceptions of abduction have affinities to both of these versions of abduction because of historical reasons (Hanson especially developed his ideas by using Peirce's conceptions). But still, I would say that neither of them is an exact fit to Peirce's conceptions of abduction. Peirce's early writings of abduction are in some sense close to the IBE-model (cf. Magnani 2001, 25-26). According to this evidential sense, abduction is concentrated on the justification of a hypothesis, although abduction is a (weak) form of inference. But the main difference with IBE is that Peirce did not concentrate much on the comparison between various hypotheses. There are *some* formulations of abduction where this kind of a comparison is taken somewhat into account:

> "The first starting of a hypothesis and the entertaining of it, whether as a simple interrogation or with any degree of confidence, is an inferential step which I propose to call abduction. This will include a preference for any one hypothesis over others which would equally explain the facts, so long as this preference is not based upon any previous knowledge bearing upon the truth of the hypotheses, nor on any testing of any of the hypotheses, after having admitted them on probation." (CP 6.524-

525, 1901; see also CP 7.220, 1901; CP 2.628, 1878)

Usually, however, the idea of comparing various hypotheses was implicit at most, and the basic issue was the drawing of one hypothesis on the basis of premises. It could be said that Peirce's early view was not so much the "inference to the *best* explanation" as the "inference to the explanation".

Peirce's later view of abduction concentrated more on the discovery of hypotheses (on the generative, or on the generative *and* the evaluative sense – see above). It could then be said that in the IBE-model we are dealing with the whole cycle of reasoning with the phases of abduction, deduction, and induction, or actually, a chain of these cycles (see Magnani 2001, 25). To call these cycles 'abduction' would, however, muddle the concept of abduction unnecessarily. For Peirce it was important to distinguish between these three forms of inference, and to emphasize that abduction is central in the *first* phase of inquiry. Neither did Peirce's later formulations pay attention to the comparison of different alternative hypotheses, which is essential in IBE. Peirce's later view of abduction is then something like the "inference to the *plausible/hypothetical* explanation", not to the *best* explanation.

Hanson's treatment of abduction has close affinities especially to Peirce's later view on abduction. The basic difference, however, is that Peirce's "logic of discovery" has its basis on the idea of an abductive instinct that helps humans to find good hypotheses whereas Hanson's logic of discovery does not appeal to an instinct at all. Hanson's basic claim is that scientists reason also from surprising data to explanations, and this is similar to the perceptual judgments and "seeing that". Scientists are always struggling for more intelligible patterns that would explain their data, and abduction is a basic formula for analyzing these processes conceptually.

There are then various versions of abduction. I would like to defend a pluralistic stance here. There is not just one "right" version of abduction waiting to be discovered, but different versions can enlighten various aspects of related phenomena (see also Niiniluoto 1999a, and Flach & Kakas 2000a, for various forms of abduction). Still, it is also useful to try to define the basic forms of reasoning. I think that this was also an essential feature in Peirce's programme; to try to find a basic forms of inference although there can then be various mixtures and combinations of these basic forms.

In this article I have argued that Peirce's own view of abduction developed from the evidential perspective to the view that emphasized methodeutical processes as well. According to Peirce's later view abduction is a very weak form of inference where Firstnesses and iconicity are important. The problem with this interpretation of abduction, however, is that it runs the risk of being too weak to be of any use. Peirce's own main answer to this problem in his later writings was to plead for abductive instinct, that is, a basis for the ability of human beings to find good ideas. I maintain, however, that abduction can also be made stronger

by emphasizing methodeutical aspects in the generative phase of abduction, especially by taking strategies into account; and this emphasis is one way of developing abduction on the basis of Peirce's own conceptions.

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NOTES

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1. Peirce used various names for this third mode of inference throughout his long career; *Reasoning à posteriori* (e.g. W 1:180, 1865; W 1:266-267, 1865), *Hypothesis* (e.g. W 1:283, 1865; CP 1.559, 1867; HP 2:878-879, 1900), *Abduction* (e.g. HP 2:898-899, 1901; CP 7.202, 1901; CP 5.188-189, 1903; CP 8.209, c. 1905), *Presumption* (e.g. CP 2.776-777, 1902), *Retroduction* (CP 1.68, c. 1896; RLT 141-142, 1898; CP 6.469-470, 1908; CP 8.385-388, 1913). (More thoroughly, see Bergman & Paavola, 2003-)
2. I am of course referring to a famous statement of Peirce: "Philosophy ought to imitate the successful sciences in its methods, so far as to proceed only from tangible premisses which can be subjected to careful scrutiny, and to trust rather to the multitude and variety of its arguments than to the conclusiveness of any one. Its reasoning should not form a chain which is no stronger than its weakest link, but a cable whose fibers may be ever so slender, provided they are sufficiently numerous and intimately connected." (CP 5.265, 1868)
3. Thagard also wants to name these two views differently as 'hypothesis' for the early view and 'abduction' for the later view. In my article these both are called with the same name ('abduction') mainly for the reason that although Peirce had various conceptions (and various names – see note 1) of this third mode of inference he himself was always after one, consistent conception of it, and 'abduction' is the established term nowadays.
4. My own view is that it is reasonable to see both the generation and the preliminary evaluation as essential elements of abduction. Peirce's idea of three interpretants (see e.g. CP 8.314, 1909; Liszka 1996, 24-28) could be applied here. Abduction should take into account the actual suggestions produced (cf. dynamical interpretant), and the "final" estimation of the hypothesis as a hypothesis (cf. final interpretant), but also that phase where abductive conclusion is only potential and inherent in various information and clues concerning the subject area in question (cf. immediate interpretant). The dynamical and the final interpretants would be equivalent to abduction in the generative and in the preliminary evaluative sense respectively.
5. Cf. an interesting argument by Kruse 1986, where it is maintained that abduction is the process of interpreting *indices* (typical instances being detective work and medical diagnoses). She admits, however, that when it comes to the relation between premises and conclusion, and the tentative character of abductive inference, the iconicity is prevalent (ibid., 438-440).
6. 'Maybe', or 'possibility' are notoriously difficult concepts here. The

idea is to have something very weak but *not* pure mathematical possibility; cf. Peirce: "The anticipation that such might be the truth, not amounting to positive assertion yet by no means sinking to a recognition of a bare possibility, was the Abductive conclusion"; and about abductive expectation: "[w]e may suppose it to be very slight, so long as it is distinctly something more than the mere recognition of a bare mathematical possibility." (PPP 283, 1903)

7. The idea that abductive conclusion is fundamentally related to many facts, and how to take them into account at the same time, is also important in the way how abductive elements are important in perceptual judgments (see CP 5.180-194, 1903). The idea is not to explain or interpret only one anomalous phenomenon but to find a *pattern*, which makes a bunch of facts understandable (Hanson 1958). In this sense abductive perceptual judgment is about putting different elements together, not just a reaction to one anomalous phenomenon (cf. CP 5.181, 1903).

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HP *Historical Perspectives on Peirce's Logic of Science. A History of Science*, 2 vols., edited by Carolyn Eisele, Mouton Publishers, Berlin, 1985.

NEM *The New Elements of Mathematics, by Charles S. Peirce*. Four volumes in five books. Edited by Carolyn Eisele. The Hague: Mouton Publishers, 1976.

PPM *Pragmatism as a Principle and Method of Right Thinking. The 1903 Harvard Lectures on Pragmatism*. Edited by Patricia Ann Turrisi. Albany: State University of New York Press, 1997.

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